CLAIMS

1. An optical recording method for recording mark length-modulated information with a plurality of recording mark lengths by irradiating a recording medium with a light, the optical recording method
5   comprising the steps of:

when a time length of one recording mark is denoted nT (T is a reference clock period equal to or less than 25 ns, and n is a natural number equal to or more than 2),

dividing the time length of the recording mark nT into

10   $\eta_1 T; \alpha_1 T, \beta_1 T, \alpha_2 T, \beta_2 T, ..., \alpha_i T, \beta_i T, ..., \alpha_m T, \beta_m T, \eta_2 T$

in that order (m is a pulse division number; $\Sigma_i(\alpha_i + \beta_i) + \eta_1 + \eta_2 = n$; α_i ($1 \leq i \leq m$) is a real number larger than 0; β_i ($1 \leq i \leq m-1$) is a real number larger than 0; β_m is a real number larger than or equal to 0; and η_1 and η_2 are real numbers between -2 and 2);

15   radiating recording light with a recording power Pw_i in a time duration of $\alpha_i T$ ($1 \leq i \leq m$); and

radiating recording light with a bias power Pb_i in a time duration of $\beta_i T$ ($1 \leq i \leq m-1$), the bias power being $Pb_i < Pw_i$ and $Pb_i < Pw_{i+1}$;

wherein the pulse division number m is 2 or more for the time
20   duration of at least one recording mark and meets $n/m \geq 1.25$ for the time length of all the recording marks

2. An optical recording method according to claim 1, wherein β_i ($1 \leq i \leq m-1$) is 0.5 to 2.5.

3.   An optical recording method according to claim 1, wherein for the time length of all the recording marks, an average of $\alpha_i T$ ($1 \leq i \leq m$) is 3 nanoseconds or more and an average of $\beta_i T$ ($1 \leq i \leq m-1$) is 3 nanoseconds or more.

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4.   An optical recording method according to claim 1, wherein for the time length of all the recording marks, $\alpha_i T \geq 3$ nanoseconds ($1 \leq i \leq m$) and $\beta_i T \geq 3$ nanoseconds ($1 \leq i \leq m-1$) for each i.

5.   An optical recording method according to claim 1, wherein for the time length of all the recording marks, $n/m \geq 1.5$ is met.

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6.   An optical recording method according to claim 1, wherein α_i + β_i ($2 \leq i \leq m-1$) or β_{i-1} + α_i ($2 \leq i \leq m-1$) takes a value of either 1.5, 2 or 2.5.

7.   An optical recording method according to claim 1, wherein for at least two recording marks with different n's, the same pulse division number m is used and, at least one of α_i ($1 \leq i \leq m$), β_i ($1 \leq i \leq m$), η_1, η_2, Pw_i

15   ($1 \leq i \leq m$) and Pb_i ($1 \leq i \leq m$) is different from any one of said at least two recording marks.

8.   An optical recording method according to claim 7, wherein

when the mark length is expressed as $nT = 2LT$ (L is an integer equal to or larger than 2), the mark is divided into a division number $m = L$

20   of sections and α_i and β_i in recording pulse sections $\alpha_i T$ and off pulse sections $\beta_i T$ (these can change according to a value of L) are defined as follows:

$$\alpha_1 + \beta_1 = 2 + \delta_1$$

$$\alpha_i + \beta_i = 2 \ (2 \leq i \leq m\text{-}1)$$

$$\alpha_m + \beta_m = 2 + \delta_2$$

(where δ_1 and δ_2 are real numbers satisfying $-0.5 \leq \delta_1 \leq 0.5$ and $-1 \leq \delta_2 \leq 1$ respectively; and when $L = 2$, only α_1, β_1, α_m and β_m exist);

5   when the mark length is expressed as $nT = (2L + 1)T$, the mark is divided into a division number $m = L$ of sections and α_i' and β_i' in recording pulse sections $\alpha_i'T$ and off pulse sections $\beta_i'T$ (these can change according to a value of L) are defined as follows:

$$\alpha_1' + \beta_1' = 2.5 + \delta_1'$$

10      $$\alpha_i' + \beta_i' = 2 \ (2 \leq i \leq m\text{-}1)$$

$$\alpha_m' + \beta_m' = 2.5 + \delta_2'$$

(where δ_1' and δ_2' are real numbers satisfying $-0.5 \leq \delta_1' \leq 0.5$ and $-1 \leq \delta_2' \leq 1$ respectively; and when $L = 2$, only α_1', β_1', α_m' and β_m' exist); and

α_1, β_1, α_m, β_m, α_1', β_1', α_m' and β_m' satisfy the following equation

15      $$\alpha_1 + \beta_1 + \alpha_m + \beta_m + \Delta = \alpha_1' + \beta_1' + \alpha_m' + \beta_m'$$

(where $\Delta = 0.8$ to 1.2)

9.   An optical recording method according to claim 8, wherein α_1, β_1, α_1' and β_1' satisfy the following equation:

$$\alpha_1 + \beta_1 + \Delta_1 = \alpha_1' + \beta_1'$$

20   (where $\Delta_1 = 0.4$ to 0.6).

10.   An optical recording method according to claim 7, wherein

when the mark length is expressed as $nT = 2LT$ (L is an integer equal to or larger than 2), the mark is divided into a division number $m = L$

of sections and α_i and β_i in recording pulse sections $\alpha_i T$ and off pulse sections $\beta_i T$ (these can change according to a value of L) are defined as follows:

$$T_{d1} + \alpha_1 = 2 + \varepsilon_1$$

5
$$\beta_{i-1} + \alpha_i = 2 \ (2 \leq i \leq m)$$

when the mark length is expressed as $nT = (2L + 1)T$, the mark is divided into a division number $m = L$ of sections and α_i' and β_i' in recording pulse sections $\alpha_i'T$ and off pulse sections $\beta_i'T$ (these can change according to a value of L) are defined as follows:

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$$T_{d1}' + \alpha_1' = 2 + \varepsilon_1'$$

$$\beta_1' + \alpha_2' = 2.5 + \varepsilon_2'$$

$$\beta_{i-1}' + \alpha_i' = 2 \ (3 \leq i \leq m-1)$$

$$\beta_{m-1}' + \alpha_m' = 2.5 + \varepsilon_3'$$

(where when $L = 2$, $\beta_1' + \alpha_2' = 2.5 + \varepsilon_2'$ or $\beta_1' + \alpha_2' = 3 + \varepsilon_2'$; T_{d1} and T_{d1}' are

15 almost constant real numbers between -2 and 2, not dependent on L; and ε_1, ε_1', ε_2' and ε_3' are real numbers between -1 and 1); and

β_1, α_2, β_{m-1}, α_m, β_1', α_2', β_{m-1}' and α_m' satisfy the following equation

$$\beta_1 + \alpha_2 + \beta_{m-1} + \alpha_m + \Delta_2 = \beta_1' + \alpha_2' + \alpha_{m-1}' + \alpha_m'$$

(where $\Delta_2 = 0.8$ to 1.2).

20   11.   An optical recording method according to claim 10, wherein for L equal to or more than 3, $\beta_1' = \beta_1 +$ approximately 0.5, $\beta_{m-1}' = \beta_{m-1} +$ approximately 0.5, $\alpha_1 = 0.8\alpha_1'$ to $1.2\alpha_1'$, $\alpha_m = 0.8\alpha_m'$ to $1.2\alpha_m'$ and $\beta_m = 0.8\beta_m'$ to $1.2\beta_m'$.

12. An optical recording method according to claim 8, wherein in recording a mark with the mark length of nT = 2T or 3T, the mark is divided into a division number m = 1 of sections.

13. An optical recording method according to claim 8, wherein when L is larger than 3, α_i is held constant at $\alpha_i = \alpha c$ and $\alpha i'$ is held constant at $\alpha_i' = \alpha c'$ for $2 \leq i \leq m-1$.

14. An optical recording method according to claim 13, wherein when L is larger than 3, αc and ac' are constant, not dependent on L.

15. An optical recording method according to claim 13, wherein when L is larger than 3, $\alpha c = \alpha c'$.

16. An optical recording method according to claim 8, wherein when L is larger than 3, each of T_{d1}, T_{d1}', α_1, α_1', β_1, β_1' takes a constant value.

17. An optical recording method according to claim 8, wherein when L is larger than 3, each of α_m, α_m', β_m and β_m' takes a constant value.

18. An optical recording method according to claim 8, wherein by using a first reference clock 1 with a period of T and a second reference clock 2 with a period of T, which is shifted 0.5T from the first reference clock, α_i ($1 \leq i \leq m$) is generated in synchronism with a reference clock 3 with a period of 2T that is produced by dividing the reference clock 1, and α_i' ($2 \leq i \leq m-1$) is generated in synchronism with a reference clock 4 with a period of 2T that is produced by dividing the reference clock 2.

19. An optical recording method according to claim 8, wherein

for all L, a delay time T_{d1} with respect to a front end of a mark length to be recorded is provided at rising edges of recording pulses $\alpha_1 T$ and $\alpha_1' T$;

a reference time T_{sync} corresponding to a clock mark formed at a

5   predetermined position on a recording track is generated;

a modulation signal corresponding to each mark length and space is generated by taking the reference time T_{sync} as a start point;

four reference clocks are generated, the four reference clocks being a reference clock 1a with a period of 2T which is generated with the delay

10   time T_{d1} from the reference time T_{sync} taken as a start point, a reference clock 2a with a period of 2T which leads the reference clock 1a by 0.5T, a reference clock 1b with a period of 2T which leads the reference clock 1a by 1T, and a reference clock 2b with a period of 2T which leads the reference clock 1a by 1.5T;

15   when recording a mark of nT = 2LT, gate groups G1a and G1b corresponding to timings of $\alpha_1 T$, $\alpha_i T$ ($2 \leq i \leq m-1$) and $\alpha_m T$ sections are generated in synchronism with either the reference clock 1a or 1b;

when recording a mark of nT = (2L + 1)T, gate groups G2a and G2b corresponding to timings of $\alpha_1' T$, $\alpha_i' T$ ($2 \leq i \leq m-1$) and $\alpha_m' T$ sections are

20   generated in synchronism with either the reference clock 2a or 2b;

when n is even, a gate G3 of $\Sigma(\alpha_i + \beta_i)T$ is generated with the delay time T_{d1} from the front end of the nT mark taken as a reference;

when n is odd, a gate G4 of $\Sigma(\alpha_i' + \beta_i')T$ is generated with the delay

time T'_{d1} from the front end of the nT mark taken as a reference;

a time that elapses from the reference time T_{sync} as a start point to the front end of the nT mark is counted as the number of reference clocks T;

when the elapsed time is an even number times the reference clock T, the gate signal group G1a or G2b is selected according to whether n is even or odd;

when the elapsed time is an odd number times the reference clock T, the gate signal group G1b or G2a is selected according to whether n is even or odd;

When both G3 and G4 are off, recording light with an erase power Pe is radiated;

when either G3 or G4 is on, recording light with a bias power Pb is radiated;

when G3 and G1a are on at the same time, recording light with a recording power Pw is radiated in response to a G1a-on section;

when G3 and G1b are on at the same time, recording light with a recording power Pw is radiated in response to a G1b-on section;

when G4 and G2a are on at the same time, recording light with a recording power Pw is radiated in response to a G2a-on section; and

when G4 and G2b are on at the same time, recording light with a recording power Pw is radiated in response to a G2b-on section.

20. An optical recording method according to claim 10, wherein for all L, a delay time T_{d1} or T_{d1}' with respect to a front end of a mark

length to be recorded is provided at rising edges of recording pulses $\alpha_1 T$ and $\alpha_1''T$;

a reference time T_{sync} corresponding to a clock mark formed at a predetermined position on a recording track is generated;

a modulation signal corresponding to each mark length and space is generated by taking the reference time T_{sync} as a start point;

four reference clocks are generated, the four reference clocks being a reference clock 1a with a period of $2T$ which is generated from the reference time T_{sync} taken as a start point, a reference clock 2a with a period of $2T$ which leads the reference clock 1a by $0.5T$, a reference clock 1b with a period of $2T$ which leads the reference clock 1a by $1T$, and a reference clock 2b with a period of $2T$ which leads the reference clock 1a by $1.5T$;

when recording a mark of $nT = 2LT$, gate groups G1a and G1b corresponding to timings of $\alpha_1 T$, $\alpha_i T$ ($2 \leq i \leq m-1$) and $\alpha_m T$ sections are generated in synchronism with either the reference clock 1a or 1b;

when recording a mark of $nT = (2L + 1)T$, gate groups G2a and G2b corresponding to timings of $\alpha_1'T$, $\alpha_i'T$ ($2 \leq i \leq m-1$) and $\alpha_m'T$ sections are generated in synchronism with either the reference clock 2a or 2b;

when n is even, a gate G3 of $\Sigma(\alpha_i + \beta_i)T$ is generated with the delay time T_{d1} from the front end of the nT mark taken as a reference;

when n is odd, a gate G4 of $\Sigma(\alpha_i' + \beta_i')T$ is generated with the delay time T_{d1} from the front end of the nT mark taken as a reference;

a time that elapses from the reference time T_{sync} as a start point to

the front end of the nT mark is counted as the number of reference clocks T;

when the elapsed time is an even number times the reference clock T, the gate signal group G1a or G2b is selected according to whether n is even or odd;

5   when the elapsed time is an odd number times the reference clock T, the gate signal group G1b or G2a is selected according to whether n is even or odd;

When both G3 and G4 are off, recording light with an erase power Pe is radiated;

10   when either G3 or G4 is on, recording light with a bias power Pb is radiated;

when G3 and G1a are on at the same time, recording light with a recording power Pw is radiated in response to a G1a-on section;

when G3 and G1b are on at the same time, recording light with a

15   recording power Pw is radiated in response to a G1b-on section;

when G4 and G2a are on at the same time, recording light with a recording power Pw is radiated in response to a G2a-on section; and

when G4 and G2b are on at the same time, recording light with a recording power Pw is radiated in response to a G2b-on section.

20   21. An optical recording method according to claim 8, wherein when performing a mark length modulation scheme recording on the same recording medium by using a plurality of linear velocities v while keeping v x T constant,

for L equal to or greater than 2, the periods of $(\alpha_i + \beta_i)T$ and $(\alpha_i' + \beta_i')T$ in $2 \leq i \leq m-1$ are kept constant independently of the linear velocity, Pw_i, Pb_i and Pe in each i are kept almost constant independently of the linear velocity, and α_i and α_i' $(2 \leq i \leq m)$ are decreased as the linear velocity lowers.

22.   An optical recording method according to claim 10, wherein when performing a mark length modulation scheme recording on the same recording medium by using a plurality of linear velocities v while keeping v x T constant,

for L equal to or greater than 2, the periods of $(\beta_{i-1} + \alpha_i)T$ and $(\beta_{i-1}' + \alpha_i')T$ in $2 \leq i \leq m$ are kept constant independently of the linear velocity, Pw_i, Pb_i and Pe in each i are kept almost constant independently of the linear velocity, and α_i and α_i' $(2 \leq i \leq m)$ are decreased as the linear velocity lowers.

23.   An optical recording method according to claim 21, wherein $\alpha_i T$ and $\alpha_i'T$ $(2 \leq i \leq m-1)$ are kept almost constant independently of the linear velocity.

24.   An optical recording method according to claim 1 , wherein the erase power Pe of $Pb_i \leq Pe \leq Pw_i$ $(1 \leq i \leq m)$ is radiated in a time length of the spaces.

25.   An optical recording method according to claim 1 , wherein the recording medium is a phase change type optical recording medium in which a crystal state is taken as an unrecorded/erased state and an amorphous state is taken as a recorded mark.

26.   An optical recording method according to claim 1, wherein for

the time length of all the recording marks, $4 \geq n/m \geq 1.5$, $\Sigma_i(\alpha_i) \leq 0.6n$ and $Pb_i/Pe \leq 0.2$ are satisfied.

27.   An optical recording method according to claim 1, wherein the linear velocity during recording is 10 m/s or higher and a minimum mark

5   length is less than 0.8 μm.

28.   An optical recording method according to claim 1, wherein a wavelength of the recording light is less than 500 nm, a numerical aperture of a lens for focusing the recording light is 0.6 or more, and the minimum mark length is less than 0.3 μm.

10   29.   An optical recording method according to claim 1, wherein the mark length modulation scheme is an 8-16 modulation scheme or a (1, 7)-RLL-NRZI modulation scheme.

30.   An optical recording method according to claim 1, wherein the mark length modulation scheme is an EFM modulation scheme in which the

15   recording is performed by setting the linear velocity during recording to 10 or more times a CD reference linear velocity of 1.2 m/s to 1.4 m/s and keeping the recording linear density constant.

31.   An optical recording method according to claim 1, wherein the mark length modulation scheme is an EFM modulation scheme in which the

20   recording is performed by setting the linear velocity during recording to two or more times a DVD reference linear velocity of 3.49 m/s and keeping the recording linear density constant.

32.   A phase change type optical recording medium recorded by the

optical recording method claimed in claim 1, the phase change type optical recording medium having a recording layer made of $M_zGe_y(Sb_xTe_{1-x})_{1-y-z}$ alloy (where $0 \leq z \leq 0.1$, $0 < y \leq 0.3$, $0.8 \leq x$; and M is at least one of In, Ga, Si, Sn, Pb, Pd, Pt, Zn, Au, Ag, Zr, Hf, V, Nb, Ta, Cr, Co, Mo, Mn, Bi, O, N and S).

5   33.   An optical recording method according to claim 6, wherein α_i + β_i ($2 \leq i \leq m-1$) or $\beta_{i-1} + \alpha_i$ ($2 \leq i \leq m-1$) is kept constant independently of a real number i.

34.   An optical recording method according to claim 33, wherein α_i + β_i ($2 \leq i \leq m-1$) or $\beta_{i-1} + \alpha_i$ ($2 \leq i \leq m-1$) takes a value of 2 independently of a real

10   number i, further wherein $\alpha_i = \alpha c$ with respect to any one of i in a range of $2 \leq i \leq m-1$, said αc being a constant value.

35.   An optical recording method according to claims 33 or 34, wherein α_i ($2 \leq i \leq m-1$) is kept constant in the time length of the recording mark with having a pulse division number m being at least 3.

15   36.   An optical recording method according to claim 7, wherein said at least two recording marks with different n's have each time length of the recording mark such that said each time length is adjacent to another.

37.   An optical recording method according to claim 36, where at least one of $(\alpha_1 + \beta_1)T$ and $(\alpha_m + \beta_m)T$ is different from any one of the at least

20   two recording marks with different n's.

38.   An optical recording method according to claim 36, where at least one of $(\beta_1 + \alpha_2)T$ and $(\beta_{m-1} + \alpha_m)T$ is different from any one of the at least two recording marks with different n's.

39. An optical recording method according to claim 7, wherein $\alpha_i + \beta_i$ (2≤i≤m-1) or $\beta_{i-1} + \alpha_i$ (2≤i≤m-1) takes a value of 2 independently of a real number i.